TEST LABORATORY

MONTHLY

PROGRESS REPORT

March 1, 1967 through March 31, 1967

GEORGE C. MARSHALL SPACE FLIGHT CENTER

HUNTSVILLE, ALABAMA

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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INDEX

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March 1, 1967 through March 31, 1967

SYSTEMS TEST DIVISION

COMPONENTS AND SUBSYSTEMS DIVISION

ADVANCED FACILITIES PLANNING OFFICE

I. FACILITIES

GEORGE C. MARSHALL SPACE FLIGHT CENTER
TEST LABORATORY
MONTHLY PROGRESS REPORT
SYSTEMS TEST DIVISION
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I. SATURN IB

A. S-IB-9 Stage

1. Test SA-44, a scheduled duration test, was performed on March 7, 1967. The test was unsuccessful and lasted approximately three seconds. Cutoff occurred because an improperly installed patch panel connection for a redlined measurement caused the digital data acquisition automatic cutoff system to react to an erroneous signal.

2. Test SA-45, a duration test, was performed also on March 7, 1967. The test was successful and lasted approximately 145.5 seconds. All stage and facility systems performed satisfactorily.

3. Stage S-IB-9 was removed from the Static Test Tower East on March 14, 1967, loaded on the barge Palaemon, and shipped to the Michoud Assembly Plant.

B. H-1 Engine

1. Cleaning, special testing, and modification of the H-1 engine hydraulic system were accomplished at the Power Plant Test Stand. Modification included the removing of accumulator high pressure piston, sealing the dynamic seal vent port, and disconnecting auxiliary hydraulic pump.

2. Test P1-494 was conducted at the Power Plant Test Stand on March 20, 1967, utilizing engine H-7057 for a duration of 40.0 seconds. The test objective was to demonstrate starting the engine without auxiliary pump running and without accumulator precharge. The engine was gimbaled without damage to the system under these conditions.

C. S-IVB Stage

1. S-IVB-209 arrived at the Sacramento Test Center on March 9, 1967, and was installed in the Vertical Checkout Laboratory. Douglas Aircraft Company will perform some pre-static checkout in the Vertical Checkout Laboratory prior to transferring the stage to Beta I for acceptance firing on June 7, 1967. Transfer is scheduled after the firing of S-IVB-503 (new).

2. Approval has been given for Douglas Aircraft Company to rebuild the Beta III Test Stand. According to the latest schedule, S-IVB-210 will be the first stage to be tested on the rebuilt stand. This firing is scheduled for November 1, 1967.

3. There will be five stages at Sacramento when S-IVB-206 arrives from Kennedy Space Center on April 13, 1967. The stages are S-IVB-206, -207, -208, -209, and -503 (new).

II. SATURN V

A. S-IC Stage

1. The S-IC-S fuel tank was installed in the S-IC Test Stand on March 10, 1967. The hydrostatic tests were delayed due to changes made in the instrumentation mounting requirements and problems in the R-P&VE data receiving station. The tests are now scheduled for April 10 and 11, 1967.

2. Two successful static firings of the S-IC-T/4 stage were accomplished by Boeing at Mississippi Test Facility. The tests were performed on March 3 and 17, 1967, having a mainstage duration of 15 and 60 seconds, respectively, as planned. The S-IC-T stage was removed from the test stand on March 30, 1967, and loaded on the barge for return to Marshall Space Flight Center.

B. F-1 Engine

Test FW-060 was conducted at the West Area F-1 Test Stand on March 13, 1967, with F-1 engine S/N F-6049 for a mainstage duration of 40 seconds. Cutoff was initiated by the facility panel operator as planned. Primary purpose of the test was to evaluate the effects of truck delivery on flight engine performance. This engine is being held in the test stand for a possible additional firing due to an unexplained shift in performance between tests at Edwards Rocket Test Site and Marshall Space Flight Center.

C. S-II Stage

1. S-II-1 static firing test data indicated that flight acceleration would cause an interference problem between the LOX prevalve relief in the No. 5 feed duct and the thrust cone cruciform. A decision was made to remove the relief feature of the No. 5 LOX prevalve on S-II-1 and subsequent stages. A 2.5 seconds time delay was incorporated in the No. 5 LOX prevalve closing circuit to reduce the relief capability needed at engine cutoff. The stage modification was tested on the Battleship stage during Test No. 42 prior to implementation on S-II-2. No problems were encountered.

2. Test No. 42 was conducted on the S-II Battleship stage on March 17, 1967, for a mainstage duration of 29 seconds. Cutoff was initiated automatically from gas generator over temperature (GGOT) indication on Engine No. 2 caused by failure of the augmented spark ignition (ASI) chamber pressure sensing line at a faulty braze joint. This resulted in hot gases impinging on the GGOT instrumentation line and fire detection system wire harness. The GH_2 start tank vent and relief valve and GH_2 start tank insulation were damaged by the hot gases.

3. The S-II-2 stage and GSE modification period (V2-300) was terminated on March 4, 1967, with several minor modifications uncompleted due to mod kits not being delivered on schedule. The pre-static stage and GSE checkout operations were initiated at Mississippi Test Facility on March 4, 1967. The completion of pre-static checkout was scheduled on March 23, 1967; however, a decision to replace the LOX vent line delayed the completion of the checkout operations until March 29, 1967. All ASI pressure sensing lines were X-rayed on March 3, 1967, due to the faulty braze problem encountered during the Battleship Test No. 42. Two ASI pressure lines were found with faulty braze joints. All ASI lines have since been cut and welded to prevent any further leak problems. The first static firing, originally scheduled for March 25, 1967, was re-scheduled for March 31, 1967, due to a decision to change the LOX vent line internal to the LOX tank on March 23, 1967. The firing attempt on March 31, 1967, was scrubbed at approximately T-10 minutes when the No. 1 LH_2 prevalve froze open and No. 5 re-circulation pump failed. After the scrub a chamber chill test was performed disclosing a restriction in the No. 3 chamber chill line.

D. S-IVB Stage

1. The S-IVB-503 (new) acceptance firing has slipped to April 26, 1967, due to Marshall Space Flight Center direction to conduct a single burn acceptance test in lieu of a re-start test. Douglas Aircraft Company needs an extra week to re-work the firing tapes which have been made for a re-start test. After the stage firing, propellants will be re-tanked to the 70% level and the O_2/H_2 burner will be fired to verify operation as part of the stage systems.

2. Checkout of the O_2/H_2 burner system installed on the S-IVB Battleship stage at Marshall Space Flight Center was completed. The GN_2 ejector system was made to operate correctly by installation of an external downstream sensing line. Due to leaks on the burner LH_2 supply line, this line was replaced with an entirely new vacuum jacketed all stainless steel line. After the new line had been installed, subsequent LH_2 loading tests provided proof of its proper operation. On March 30, 1967, the first O_2/H_2 burner test, No. S-IVB-H01, was conducted for a duration of 37.9 seconds. Post-test review of the data indicated normal burner performance during ignition, run and cutoff. Due to an apparent error in the control wiring, the re-pressurization system operation could not be properly evaluated.

III. APOLLO APPLICATIONS

A. Lunar Drill Program

Scopes of work for the Moderate Depth Lunar Drill program were finalized and transmitted to Northrop, Westinghouse, and Joy Manufacturing Company. Five tests were conducted at Marshall Space Flight Center with the piston type compressor to further analyze problems with valves and bearing lubrication.

B. LSSM Project

1. The Mobility Test Articles (MTA's) are scheduled to be shipped from Yuma Proving Ground (YPG) on April 11, 1967. A building, test course, and power supply for the vehicles are in preparation at Marshall Space Flight Center. The Bendix MTA data reduction is approximately 95% complete. General Motors' data will be processed this month.

2. The LSSM wheel and drive test program by General Motors is approximately 50% complete. The wire mesh wheel and harmonic drive (General Motors' version) tests are complete. Two harmonic drives failed. Twenty-five percent of the wires in the wheel are broken and approximately 30% of the thread rivets had come loose before the conclusion of the 100,000 wheel revolution test. The metal elastic wheel and nutator drive (Bendix version) tests were scheduled to resume on March 30, 1967, after an initial failure and re-work of the nutator drive.

3. During this period, eleven meetings were held to define the RFP for the LSSM and to compile its content in rough draft. It has been concluded that the 1/6g simulator tests will not be a part of the technical requirements of the RFP due to the status of design and to the lead time required to provide an adequate facility. Dynamic data for the program will be obtained from math models and vehicle model tests until 1/6g simulators are better defined. Additional meetings were held to define the number and type of major test articles required to provide a technically acceptable test plan. The test plan will require four test articles; this does not include an MTA, but it does include one test article that can be used for integration with the launch vehicle. Problems exist in defining the total number and type of required vehicles since definitive program requirements beyond the development phase have not been provided.

Daniel H. Driscoll, Jr.

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I. SATURN IB

A. S-IB Stage

1. 200K H-1 Turbopump Testing

The H-1 Turbopump Facility supports R-P&VE in S-IB propellant feed system studies. The facility provides S-IB vehicle system simulation including prevalves, suction ducts, turbopump, high pressure ducts, and main engine valves.

Evaluation of Test C-039-4 data of the Fuel Additive Test Series was completed. The FR-3 friction reduction additive which was mixed with the fuel did not improve feed system performance. Fuel samples indicate that the FR-3 did not mix homogeneously with the RP-1. An intermediate mixing system was installed during this reporting period to obtain a proper FR-3/RP-1 mixture. Also, a GN_2 bubbling/agitation system was installed on the main fuel tank. Testing will resume during the next reporting period.

II. SATURN V

A. S-IC Stage

1. F-1 Turbopump Testing

The F-1 Turbopump Facility provides the capability to perform checkout, calibration, qualification, and development tests on S-IC/F-1 Turbopump propellant feed systems. This facility contains a gas generator driven F-1 Turbopump which is mounted on a thrust chamber and simulates the S-IC flow system from the suction duct inlets to the main shutoff valves of the engine.

Test C-006-67 was conducted at the F-1 Turbopump Test Facility. This test concluded the "Fuel Pump Inlet Fairing Bolt" test program. The object of this test series was to determine if unknown hydrodynamic loads are experienced by an F-1 Turbopump fuel inlet fairing and its retaining bolts during turbopump operation. Preliminary examination of data indicates that no unusual or detrimental forces occur.

An R&D 6 x 6 impeller Turbopump is currently being assembled by Rocketdyne for testing at the F-1 Turbopump Facility. The purpose of this test program is to determine the operating characteristics of the 6 x 6 fuel and LOX impellers in comparison with the standard 6-blade impellers. Preparations for testing this pump are currently underway at the F-1 Turbopump facility.

Additional testing of a new, Teflon bearing design for a 17-inch turbine-type S-IC LOX flowmeter will begin during the month of April. These flowmeter bearings will be tested in conjunction with a Flexonics LOX Outboard PVC. The Teflon flowmeter bearings were delivered to MSFC on March 27, 1967 after considerable delay.

2. F-1 Heat Exchanger Development Tests

The purpose of this program is to establish reliability and to verify the design of the F-1 heat exchanger.

No tests were conducted during this report period. As stated in the last progress report, there are two tests planned to verify the test results from Phase II testing before terminating the test program and placing the test stand in a standby condition. However, the Prototype gas generator used in this test program developed a leak, exceeding specifications, past the LOX ball valve bellows. A new bellows is presently being installed, and the tests will be completed during the month of April.

3. F-1 Gas Generator Development Tests

A project was established to conduct tests on an F-1 gas generator with different injector configurations. The objectives of the program are to alleviate detrimental pressure oscillations, reduce continued combustion in the turbine manifold, and to increase gas generator performance.

Three tests of 30 seconds duration each were conducted during this report period. These tests utilized the P&VE-designed double-swirl cup injector and were operated at LOX/fuel ratios of .35 with fuel flows of 100, 110, and 120 lbs/sec respectively. All three tests were successful. The data was transmitted to the requestor for evaluation and analysis. This leaves five tests to complete the planned test series after which the program will be terminated. The cell is operational and testing is continuing.

4. F-1 Turbopump Seal Tests

This program is being conducted to develop and improve LOX turbopump rotating shaft seals. This will be accomplished by comparing wear characteristics of various materials and configurations in the seal test fixture at simulated turbopump operating conditions.

One test was conducted with the modified labyrinth seal; however, excessive leakage past the secondary (Kel-F Labyrinth seal) seal still existed. This condition does not allow testing of the rotating shaft seal.

At the present time P&VE is evaluating the advisability of continuing this program. Termination is being considered.

5. LOX Stratification

This program was requested by P&VE to verify analytics used to predict LOX Stratification in spherical containers using LN_2 for simulation.

An attempt will be made to correlate LOX stratification data with previously obtained LN_2 stratification data.

Tests C-025-16 and 17 were successfully conducted during this report period. Test C-025-15 is to be rerun the week of April 7, 1967. Estimated completion date of testing is April 7, 1967.

6. LOX Depletion Testing

The purpose of this program is to support R-TEST-SP in a study of the LOX depletion characteristics during ground static tests with the ultimate goal of the combined effort to predict the LOX depletion characteristics.

Facility buildup is in progress. Test start date slipped to May 22, 1967 due to testing on the adjacent LH_2 Slosh Facility.

B. S-II Stage

1. S-II Insulation

B-Cell Position 1 - 70-Inch Tank Insulation and Thermal Ullage Study:

The combined test programs were requested by P&VE Laboratory to (1) determine if the Dual Seal Insulation field repair techniques are structurally adequate under thermal cycling, (2) determine what effect tank geometry and insulation closeouts have on the thermal performance and structural integrity of the insulation under simulated aerodynamic heating, and (3) conduct a LH_2 ullage thermodynamic study.

All tests have been completed and a report is being prepared.

C. S-IVB Stage

1. J-2X Turbopump Test

This project is to further the development and verify the performance of advanced J-2 turbopump and subsystems. Test Position 501 is being prepared for this project.

Shop progress has been virtually at a stand still due to higher priority programs. The only work done on the 501 position was in those areas directly effecting the operation of the 502 (J-2 Thrust Chamber) position. To date, shop work is complete on the burn pond, new burn stack at the LH_2 storage area, miscellaneous piping at the LH_2 storage area and LOX storage area.

Because of higher priority Saturn V work, it is not possible to establish a firm buildup completion schedule.

2. J-2X Thrust Chamber Throttling Tests

This program was established to evaluate the throttling characteristics of J-2 thrust chambers. Engine thrust excursions of 5K to 200K (Sea Level) are contemplated. This will be accomplished in a 2-phase program.

Phase I consists of facility design, facility activation, and initial J-2X testing. The facility utilizes pressurized propellant tanks and throttle valves to control the engine thrust level. The activation test firings will include ignition, partial transition, full transition, and mainstage of a tubular wall J-2 thrust chamber with a ceramic coating to increase combustion zone durability.

The initial J-2X testing will utilize a J-2 thrust chamber with tapoff capability. The thrust chamber will be evaluated at steady state conditions, four to six mixture ratios, and between 5K and 200K SL thrust levels (no dynamic throttling).

Phase II will consist of dynamic throttling of J-2 thrust chamber with and without hot gas tapoff capabilities, at four to six mixture ratios, and between 5K and 200K SL thrust. These tests will define engine and facility operating capabilities and will permit thrust chamber and tapoff optimization.

At present, buildup is 95% complete. The pressurization and propellant systems calibration and checkout is about 25% complete. The propellant system calibration should be completed within one week and testing should begin before April 15.

3. LH_2 Slosh Testing

This program supports P&VE in the areas of LH_2 and LOX propellant feed systems studies in an ellipsoidal tank.

No tests were conducted during the month of March. The S-IVB Fuel Prevalve tests did not begin on schedule due to a delay in getting the adapters for the valve. All hardware has now been installed and testing is scheduled to begin the first part of April.

4. S-IVB LOX and Fuel Tank Relief Valves

The test objective for the S-IVB relief valve is to determine the valve operating characteristics with simulated flight vehicle environment. Emphasis will be placed on determining possible valve chatter during relief modes.

Two valves were tested; both performed satisfactorily. No chatter during relief mode was detected.

This program was completed. The test report for the S-IVB LOX Tank Relief Valve was submitted on March 27, 1967 for concurrence and approval.

5. S-IVB Auxiliary Propulsion System Testing

The S-IVB Auxiliary Propulsion System Test Program was requested by P&VE Laboratory for conducting tests on upper stage ullage and attitude control engines at simulated vacuum environments.

Three test series (Tests C-008-C-1-14, 15, and 16) were conducted on C-1 engine S/N 813 at a simulated altitude of 140,000 feet during this reporting period. Test 14 consisted of a series of 5-second steady state firings in which the combustion chamber pressure was varied from 87.5 to 93.5 psia in an effort to determine at what Pc level the 300 cps combustion instability terminated. Pc oscillations of ±2 psi persisted for the duration of the firing at Pc = 87.5 psia, but no oscillations were observed in the tests at the higher Pc levels. Test 15 was a 5-second steady state firing at the 80 psia Pc level; oscillations of ±11 psi persisted for the duration of the test. Test 16 consisted of a 5-second steady state firing, a 25-second steady state firing, 10 pulses of 63 ms on - 437 ms off, and 50 pulses of 63 ms on - 137 ms off. The steady state Pc for this test was 102 psia, and no Pc oscillations were observed.

The above described tests completed the present single engine C-1 test series. APS Module System Tests utilizing three C-1 engines are scheduled for late April.

D. Ground Support Equipment

1. LC-39 Service Arms

a. S-IC Intertank (Set III) - This preflight arm supplies the vehicle S-IC stage with lox fill and drain service, as well as personnel access to the vehicle. The arm has automatic capabilities to allow reconnection in case of a mission hold or abort.

The normal test program was interrupted in order to run a series of arm swing tests using a modified deceleration valve and a new cam (cam B). Modifications to the deceleration valve consisted of removing the pressure compensator spool, the sequencer spool and plugging a relief valve orifice. With this system, arm swing times were satisfactory; however satisfactory control of the arm swing characteristics could not be achieved. Further tests were conducted using a modified cam (Cam C) in conjunction with the modified deceleration valve. Satisfactory arm swing times and swing characteristics were achieved. The new cam (cam C) and the modified deceleration valve were also successfully tested on S-IC forward arm, S-IVB forward arm, and service module arm.

The test program on the S-IC intertank resumed on 3/27/67.

b. S-IC Forward (Set III) - This preflight arm supplies the forward end of the S-IC stage with electrical, pneumatic, air conditioning services and personnel access.

During this report period tests were conducted to determine the arm swing characteristics when using a modified deceleration valve and cam (cam C) (ref. II. D. 1. a. above).

c. S-II Intermediate (Set II) - This inflight service arm provides air conditioning, electrical, pneumatic, LH_2, and lox services to the S-II stage. The LH_2 and lox fill lines have independent connections to the stage while the remainder of the service lines in the arm are connected to the stage through one common carrier

The set II arm was installed in the test facility on March 28, 1967. Tests on the umbilical lanyard withdrawal system are scheduled to start April 5, 1967.

d. S-II Forward (AA-05-01) - This inflight service arm provides air conditioning, electrical, and pneumatic services, plus a GH_2 vent for the S-II stage. All connections to the stage are through a common carrier.

Arm AA-05-01 was returned to MSFC after being used in the Saturn V 500F wet test. The service arm was modified at MSFC to a lanyard withdrawal system, which replaced the dual cylinder withdrawal system used on AA-05-02 and AA-05-03. The conversion to the lanyard system was completed on March 14, 1967, and the arm was installed in the test area on March 15, 1967. During preliminary checkout tests it was found that the hydraulic withdrawal cylinder (75M06505) would not re-extend after being operated to the retract position.

Investigation revealed that cylinder rod bent during the withdrawal operation as a result of a discrepancy in the pivot point location of the hydraulic cylinder. KSC Design is correcting this problem. It is planned to start the test program on April 3, 1967.

e. S-IVB Aft (AA-06-01) - This inflight service arm provides LO_2 and LH_2 fill and drain services to the S-IVB stage. AA-06-01 was returned to MSFC after being used in the Saturn V 500F wet test. The service arm was modified at MSFC to a lanyard withdrawal system, which replaced the dual cylinder withdrawal system used on AA-06-02 and AA-06-03. The conversion to the lanyard system was completed on March 4, 1967, and after cleaning of the system operating lines, the arm was installed on the tower simulator on March 8, 1967. Modifications to Control Console 1 and checkout of the withdrawal system were completed, and tracking tests were conducted. This series of tests, completed on March 20, 1967, revealed that proper adjustment of the primary lanyard with the umbilical carrier in the fully withdrawn position did not leave sufficient slack in the lanyard to track the worst dry vehicle motions. A modification which will relocate the trunnion mount of the

hydraulic withdrawal cylinder is now in progress, and is expected to eliminate the tracking problem.

Disconnect and withdrawal tests were begun on March 20, 1967. Twenty-five tests have been conducted, including eight full systems tests. One problem encountered early in this series was the tendency of the primary lanyard cam levers to override the disconnect lever during withdrawal. This situation resulted in breaking welds on both sides of the interface bracket. The problem was traced to excessive compression of the rubber stops on the disconnect lever. The installation of 1/4-inch thick aluminum spacers under the rubber stops have successfully solved this problem.

Adjustment of the withdrawal system are still being made. At present, no Kemp primary firing valve is available, and arm retraction is being accomplished by the secondary system. The testing conducted thus far indicates that the lanyard withdrawal system is operating satisfactorily.

f. S-IVB Forward (Set I) - This inflight service arm provides air conditioning, electrical, pneumatic, water glycol, and LH_2 venting services to the S-IVB forward and the instrument unit (IU) carriers, as well as through the Lunar Excursion Module (LEM) carrier.

During this report period 41 instrumented R&D tests were conducted on the deceleration valve and cam. Six instrumented disconnect tests and four instrumented disconnect and withdrawal tests were also conducted.

The LEM fluid service line installation is complete with the exception of proof pressure and cleaning of the lines which will be done during refurbishment.

g. Service Module - The service module arm is an inflight arm and provides air conditioning, electrical, GH_2 venting, and water glycol cooling services to the Apollo service module umbilical connection.

The set III arm was shipped to Cape Kennedy on November 17, 1966. An Internal Note test report was distributed February 10, 1967.

The set II arm was modified to the latest drawing configuration and was installed on the test tower simulator on December 12, 1966. However, during the installation, the arm truss was damaged and the arm removed for repairs. The truss diagonals were repaired (R-TEST-RT) and the arm was reinstalled in the test stand on January 12, 1967. Testing is now in progress. The normal test program was interrupted due to a special series of deceleration valve tests for KSC. These tests have been concluded and systems and subsystems testing of the arm will resume March 30, 1967. Testing should be completed May 20, 1967.

h. LC-39 Command Module Access Arm - The LC-39 command module access arm is a preflight arm which supports an environmentally conditioned chamber through which the astronauts and service personnel can enter the Apollo spacecraft. The arm also provides a support structure for air conditioning and space suit checkout lines.

No operations of the systems have been made since February 13, 1967 due to damper arm operations and tower modifications.

Tests on the new deceleration valves are planned to be run during shutdown periods on the ML-2 damper arm and completed after shipment of the ML-2 damper arm.

2. Saturn V Damping, Retract, and Reconnect System (DRRS)

The DRRS is a system for the primary purpose of damping the Saturn V vehicle oscillation due to vortex shedding. The system has the capability of automatic extension, connection, disconnect, and retraction as well as damping oscillations. The test will be conducted for P&VE Lab to qualify the system prior to its use on LC-39.

The ML-2 DRRS truss assemblies, crossbeam and other miscellaneous hardware were received from ME Lab on March 23, 1967 and assembled on March 24, 1967. However, all of the components necessary to install the system in the test tower have not been received. The control console, latchbacks, etc. were delivered on March 27, 1967. All units received except the control console were installed. The control console was returned to ME Lab by R-QUAL for rework on March 28, 1967.

The arm assembly will be installed in the test stand upon receipt of the static cable support brackets. Expected delivery is April 3, 1967.

Based on the above date testing is planned to begin on April 5, 1967.

3. Auxiliary Damping, Retract, and Reconnect System (ADRRS)

The ADRRS is mounted on the Mobile Service Structure (MSS) at the 326-foot level, and is used to dampen vehicle oscillations caused by vortex shedding. This damping system will be used when the vehicle is enclosed by the MSS, whereas the primary damping system will be used during vehicle transit to the launch site and at the launch site when the MSS is not at the pad.

Damper tests on the right hand and left hand damper panels were completed on March 2, 1967 and March 8, 1967, respectively.

As reported last month, high loads were being induced on the LES leg during latching. A modification was performed to provide

an "extend" velocity of approximately 0.6 in/sec and a "retraction" velocity of approximately 2.5 in/sec. In addition, the procedure for operating the valve control panel was changed. These changes resulted in bringing the loads within the specified criteria (2,500 lbs.)

The system was returned to the ME Lab for refurbishment on March 15, 1967.

4. LC-39 Tail Service Masts

The three service masts (lox, fuel, and environmental) are located on the deck of the Mobile Launcher and are used to service the S-IC stage tail section. Mast retraction is initiated by vehicle lift-off.

Set II tail service masts (S/N 1004, 1005, and 1006) were shipped to LC-39 on October 10, 1966. An Internal Note was distributed February 27, 1967 to cover the testing program run on these masts.

Set III tail service masts (S/N 1007, 1008, and 1009) testing was completed on October 24, 1966. Refurbishment by R-TEST-RT was completed and the masts were shipped to Cape Kennedy November 30, 1966. An Internal Note is being prepared (approximately 70% complete) to cover the testing program run on this set of tail service masts.

Set I tail service masts (S/N 1001, 1002, and 1003) were received by R-TEST-RT on December 20, 1966. TSM 1-2 was delivered to R-TEST-CF on December 29, 1966 and was installed on the mounting base. TSM's 3-2 and 3-4 were delivered to R-TEST-CF and subsequently installed. A special test for R-P&VE-VO was completed in which the interface distance between the umbilical carrier mounting surface and the vehicle umbilical plate was two inches less than shown on the installation drawing. The test was run on masts 3-4 and 1-2; a flash report was written covering this test. Testing is continuing as MSFC with this new dimension as the nominal distance. Testing has stopped (3/24/67) pending mast modifications prior to left lateral and right lateral retractions. Cable retract pulleys for hood ball lock indication cables are to be relocated approximately 15 inches, toward the mast pivot point, from their present positions.

5. LC-39 Mobile Launcher Holddown Arms

The purpose of this test program for KSC is to verify the physical and functional integrity of the Saturn V holddown arms prior to installation on the mobile launcher. All four holddown arms of the second and third set with forged links have been tested and shipped to KSC. Structural testing of the fourth set of arms began August 11, 1966, and was successfully completed November 2, 1966.

This fourth set of arms is a spare set and is being retained at MSFC to serve as test bed for development of the holddown arm release

system. Synchronization tests using control panel 75M18516 and pneumatic plumbing simulating launcher installation 75M05972 and 75M05973 were successfully conducted between January 9 and February 21, 1967. Modification of arm 003 and installation of new parts required for testing the secondary release system, employing an explosive nut, is complete and preparation for this test is in process. Testing should begin on March 30, 1967. The test start date has been delayed because of a late decision by KSC to use flight configuration pneumatic separators in this test.

6. Saturn V Lift-Off Switches

This program is being conducted for KSC to insure that the liftoff switch actuator arms can signal initiation of the umbilical disconnect and service arm rotation at the required vertical distance of vehicle liftoff.

Three switches (S/N 5, 8, and 9) have been adjusted and sent to KSC. A report was released September 21, 1966. Three more switches (S/N 6, 7, and 10) have been adjusted during the acceptance testing of the switch adjusting tool (SK-17886) and were shipped to KSC on January 26, 1967. A test report was released February 20, 1967. A report on the adjusting tool has been submitted. Another switch (S/N 11) with a modified primary actuator will be tested to determine the acceptability of the modification for use at KSC. Testing of the modified actuator has been delayed because of projects with higher priority.

7. Q-Ball Cover Removal System

The purpose of the test was to demonstrate operational reliability of the system for removing the cone cover from the vehicle nose.

Testing of the first of three removal units was completed November 28, 1966. Modifications to the system were made as a result of testing and a final functional test of the modified system was conducted December 5, 1966, and unit 1 shipped to KSC. Testing on unit number 2 was completed December 30, 1966. Testing of unit number 3 was completed January 18, 1967. Unit 2 was to be shipped March 3, 1967, and unit 3 was to be shipped March 10, 1967; however, both units are being held at MSFC pending major modification to the removal system. The modifications have been initiated to eliminate interference with a damper arm and a LUT crane. An Internal Note is in progress. Further tests will be conducted in conjunction with the Primary Damper System to verify elimination of interference problems.

8. High Pressure Test Facility

a. The following test program is being conducted in the High Pressure Test Facility, building 4648:

(1) Connector Burst Test (Test Lab) - The purpose of this program is to establish a factor of safety based on burst failure for commonly used tube and pipe connections and to observe factors that affect burst or excessive leakage. Three sizes (1/2", 3/4", 1") were tested in each of the following type fittings:

(a) Male AN to flared tube

(b) Male AN with cap

(c) AN o-ring to boss

(d) Pipe-to-pipe union

Testing began on October 17, 1966, and was completed on November 25, 1966. The results have been evaluated and the report has been prepared and submitted for approval. This item will no longer appear in the progress report.

b. The following test programs are being conducted in the High Pressure Test Facility, building 4648, for the Mississippi Test Facility (I-MT-EF).

(1) CPV and MVP Relief Valves - The purpose of the testing for these two valves, manufactured by the Combination Pump and Valve Company and the Mission Valve and Pump Company, is to evaluate their operating characteristics. Testing was started on September 19, 1966, and was completed on October 21, 1966. The MVP was found unsatisfactory for its requirements; however, the CPV was found satisfactory for reduced flowrate application. The test report for the CPV valve has been written and approved. The MVP report is in progress. This item will no longer appear in the progress report.

(2) Anderson Greenwood and Company Relief Valves - The purpose of this testing is to evaluate the operating characteristics on two Anderson Greenwood and Company pneumatic pressure relief valves. The test procedure has been written and approved. Testing was interrupted because of the MTF Grove ball valves and KSC testing requiring High Pressure Test Cell instrumentation. Testing should be completed by approximately March 31, 1967. Testing to date indicates that the units have pulsating flow characteristics.

(3) Grove Ball Valves, Model M-16821 and M-16821-G - The purpose for testing these valves, manufactured by Grove Valve Company, is to evaluate flow, leakage, and closing characteristics. These valves are possible replacements for the ITT Hammel-Dahl V950 series in the high pressure systems at MTF. Testing started January 17, 1967, and was completed February 14, 1967. The units were unsatisfactory and a report is being compiled. This item will no longer appear in the progress report.

9. S-IVB Aft Withdrawal Cylinder Life Cycle Test

The purpose of this test program, for KSC, is to determine the ability of one withdrawal mechanism to "track" vehicle motion for 1,100,000 cycles. Testing began November 22, 1966, and should be completed by April 28, 1967. The completion date has changed because eight additional cylinders are to be tested.

On November 25, 1966, a teflon guide ring failed and a new teflon guide ring was installed. Testing at that time was not continued because of the differences in guide ring tolerances. A third teflon guide ring was installed and failed (excessive wear) after 8,820 cycles. After installing the fourth guide ring, made from Delrin material, testing was resumed. Ten-hour runs of continuous cycling caused temperature buildup resulting in cylinder overload. At 200,000 cycles, a GN_2 purge was initiated through the cylinder to dissipate heat. The purge, although successful, was removed at 30,000 cycles. Removing the GN_2 purge let the temperatures in the cylinder rise to 264°F which caused the Delrin bearing head ring and the guide head guide ring to melt. Both guide rings were damaged too much for further use. New serrated Delrin guide rings were fabricated, installed, and a 12-hour run of continuous cycling was successfully accomplished. Cycling is still in progress at 531,400 cycles with no further problems encountered with the modified Delrin guide rings. Six modified pneumatic cylinders for arms 4, 5, and 6 have been cycled a minimum of 30,000 continuous cycles (12 hours) each and shipped to Cape Kennedy for installation at LC-39 to support 501 and 502 vehicles.

10. Flush and Purge Truck

This test program is being conducted (for P&VE Lab) to insure that the truck will service the F-1 engine as required.

Testing was initiated December 16, 1966, and the following tests have been successfully completed: Relief valves, GN_2 system, trich tank fill, filtration and circulation, fuel jacket flush, fuel jacket purge, lox dome, hypergol cartridge, no flow, portable pump, ullage pressure, solenoid valves, emergency stop, and turbopump preservative. A revision to the unit will require a rerun of the lox dome test. Testing is 95% complete.

III. SUPPORTING RESEARCH AND TECHNOLOGY

A. Zero Gravity Test Facility

The Zero Gravity Drop Tower is utilized to assist P&VE in the study of low gravity fluid mechanics and thermodynamics phenomena. The facility is located in the Saturn V Dynamic Stand.

Seven tests were conducted during this period. These tests were conducted to obtain data on slosh wave amplification due to impulses and residual boost slosh at orbit injection.

B. S-IC Model Drop

This test program was requested by R-AS to evaluate the S-IC booster recovery concept. Testing is to be accomplished by utilizing scale models impacting on water.

The first model drop test was conducted on March 17, 1967 at a drop height of 99 feet and a model weight of 560 pounds. This first test revealed that instrumentation on the model was not located to obtain the required pressure measurements correctly. The instrumentation locations have been changed and testing is scheduled to begin the first part of April.

C. Liquid Hydrogen Super Insulation

1. The Linde Superinsulation Test on a 105-inch tank will determine the ground hold thermal performance of a vessel using Linde Superinsulation by measuring hydrogen boil-off rates. It will also verify that the tank and insulation are not leaking, prior to installation of the vessel in a vacuum chamber.

The test tank arrived from the ME Laboratory on March 14, 1967. The test buildup has been completed. Testing will start April 3, 1967.

2. This program, requested by P&VE, consists of studying the effectiveness of "super insulated" LH_2 tanks in a simulated space environment of 10^{-6} torr pressure.

Test tank No. 3 has been delivered to CTL and is being prepared for ground hold tests. Two tests will be conducted during April 1967.

30-Inch Calorimeter: The re wrapped calorimeter was returned from ME Laboratory. This program is being delayed due to higher priority work (Orbital Workshop).

D. Storable Propellant Space Engine Testing

This program was requested by R-P&VE-P to provide support for testing (1) engines to be used on Project Thermo, and (2) advanced technology engines.

Beryllium Engine: A test at altitude conditions was conducted on the Beryllium engine during this period. The data are being evaluated.

Monopropellant Engine: P&VE Laboratory has on order two 40-pound thrust engines which will be tested by Test Laboratory.

E. Jet Impingement on Water (1/2K Cluster Phase)

This program was requested by KSC to study the feasibility of launching large flight vehicles of the SATURN V and NOVA classes from off-shore sites.

Three tests (C-002-15C, 16C, and 17C) were conducted during this report period. Test 15C received a high temperature engine cutoff at 1.2 seconds after ignition. A post-test review of the engine data indicated that the engine did not "heat-up" and that the cutoff was due to an instrumentation malfunction. Test 16C was conducted at 10 nozzle exit diameters above the water's surface and had an engine nozzle expansion ratio of 10:1. Test 17C was conducted at 10 nozzle exit diameters above the water's surface and had an engine nozzle expansion ratio of 16:1. The time duration for Tests 16C and 17C was 20 seconds each. Acoustic data was obtained for the three tests.

F. Combustion Dynamics

This project investigates, at an intermediate thrust level, the combustion stability theories which have been developed analytically or at a very small thrust level. The main areas of interest are combustion stability of LOX/RP-1 and LOX/H_2 systems at the 30K and 15K thrust levels respectively.

No tests of the 30K LOX/RP-1 engine were conducted during this reporting period due to a delay in fabrication of a new injector. This is the final injector design to be tested in this program. The injector fabrication will be completed by March 31, 1967 and testing should resume in early April.

Two tests were conducted with the 15K LOX/GH_2 transpiration-cooled engine during this report period. The first test had a chamber pressure of 2,000 psig with an O/F ratio of 3.8:1. The second test developed 2,200 psig chamber pressure with an O/F ratio 4.3:1. The transpiration coolant system was modified prior to these tests to allow a greater mass flow rate. Testing will continue with the chamber pressure levels being increased in 200 psig increments until 3,000 psig has been reached.

G. Pump Inducer Development Project

This project has been requested to investigate the performance of a hubless inducer for use on future turbopumps.

Data for the tests which have been conducted is being reviewed by R-P&VE-PA. The pump inducer (LH_2 high speed) is not compatible

with the present volute and the design flow point cannot be reached. Further testing with LH_2 inducer may be resumed in early April if flow rate can be increased or if more synchronized movie for cavitation coverage is desired at lower available flow rates. R-P&VE-PAC is reviewing their requirement for continuing this program.

H. LH_2 Seal Evaluation Tests

The purpose of this test is to evaluate the sealing capability of the Conoseal and Naflex seal installed in an 18-inch diameter manhole cover of a liquid hydrogen tank. The tests will be performed with LH_2 at pressure levels of 5 to 50 psig. Leakage from each seal will be measured and recorded at each pressure level.

Test results have proven the Conoseal to perform satisfactorily. The Naflex seal, however, did not meet the requirements; it exceeded the desired leakage rates. The Naflex seal's secondary seal is very poor and elimination of the leakage there is mandatory if the leakage rates of the primary seal are to be accurately determined. It was therefore decided to obtain new Naflex seals with improved Teflon coating and also modify the test fixture to provide the possibility of measuring primary and secondary seal leakage rates. This will be accomplished in a followup program. Coordination of the followup program for this test fixture to evaluate an 18-inch diameter Naflex seal has continued. It is planned to start the followup program during the latter part of April.

I. Acoustic Studies

Acoustic Studies currently being performed at AMTF are to investigate, analyze, and evaluate the noise generating mechanisms and the resultant acoustic fields of aerodynamic flows, i.e., rocket exhaust flows. These flow fields are generated by launch vehicle propulsion systems which are large in size and power; consequently, very severe acoustic environments are created. Techniques for estimating these adverse environments in many instances are very crude or nonexistent. Therefore, it is necessary that prediction techniques be developed and verified that will adequately define the associated acoustic environment.

These test programs cannot be conducted using full-scale flow fields, but by careful consideration of dynamic similarity principles and valid scaling procedures, scale model test programs of these flow fields can be successfully performed, to accomplish the above stated objectives.

Specific programs now planned at the AMTF are:

(1) Comparison of acoustic environmental characteristics of a cone and bell-shaped engine nozzle with duplicate exit diameters.

(2) Acoustic environmental variations due to nozzle exit pressure variations for a single engine.

(3) Ground plane acoustic environment (amplitude) for static and flight operation of a 1/20th scale Saturn V vehicle configuration.

(4) Vehicle acoustic environment (phase and amplitude) for the launch condition of a 1/20th scale Saturn V vehicle configuration.

(5) Acoustic source location study of a single, undeflected, rocket exhaust flow.

(6) Saturn V, MLV acoustic environmental definition for strap-on configurations.

(7) Supplementary study of cluster effects as a function of engine separation distance and cluster diameter.

(8) Study of the three dimensional acoustic field developed by a rocket exhaust flow impingement on a deflector (uni- and bi-directional flow).

Four tests to determine the effects of varied engine nozzle geometry were conducted during this reporting period--two tests with the bell-nozzle engine and two tests with the cone-nozzle engine. This completed the planned tests for this study; however, during preliminary evaluation of the acoustic data, an unexplainable spectrum shift was detected. It was therefore determined that the two tests using the bell-nozzle engine should be repeated. These tests will be conducted as soon as weather conditions permit.

After completion of the nozzle study, testing to determine the effects of varied engine exit pressures will begin immediately.

Two tests were conducted during this reporting period on the convectively-cooled deflector. The deflector was subjected to a 10-second and a 30-second duration test. Results of both tests were satisfactory and no further testing is required.

The deflector is now ready to be used in future acoustic studies.

J. Solid Motor Particle Study

This test program is being conducted to obtain information concerning solid particle distribution, and heat transfer characteristics of plumes, from solid propellant rocket motors.

The test report is being finalized and will be distributed in April 1967. This project has been completed and will not be included in future progress reports.

K. Flame Study

This project is to obtain free stream and disturbed stream calorimetric, temperature, and pressure data, from existing Test Laboratory model rocket engine plume environments.

Fabrication of the test fixtures required for the acquisition of the requested additional total pressure and temperature data, of the engine plume, has been completed. Testing will commence when instrumentation pressure and temperature transducers are obtained and installed. Installation is scheduled to be completed by April 16, 1967.

The completion date of the Internal Note has been revised to May 19, 1967.

L. Improved Saturn V Launch Facilities (VLF-39) Model Study

This program is a specific study of existing facility capabilities (VLF-39) necessitated by the proposed use of improved Saturn V Boosters which will use five uprated F-1 Engines and 4-each "Strap-Ons" 120-inch or 156-inch Solid Rocket Motors. This study will be used to establish the extent of launch facility (VLF-39) capability and/or modifications required when using the improved Saturn V Booster Configuration.

The test program, utilizing 1/58 scale model facilities, has the following objectives:

a. Determine the environment of vehicle base and facility elements during holddown and initial lift-off.

b. Determine the environment of the mobile launcher and umbilical tower for maximum vehicle drift.

c. Determine the extent of facility modification necessary for compatibility with Improved Saturn V vehicles.

The test program will be conducted in four phases. A 1:58 scale model of the Saturn V Booster will be utilized for all four phases of the test program.

The first phase will be conducted using the Basic Saturn V Booster scale model and will serve to establish Baseline data. Phase II tests will use the same scale model Booster but with the uprated F-1 engines. Phase III will utilize uprated Saturn V scale model with 120-inch simulated Solic Motor Strap-Ons. Phase IV will use the uprated Saturn V scale model with 156-inch simulated Solid Motor Strap-Ons.

Five tests in Phase I were conducted during this report period. Data were recorded for the basic Saturn V during vertical lift-off (three tests) and during maximum drift (two tests). There are two more tests scheduled to complete testing of the lower position (120')

of the umbilical tower. At that time the tower will be lengthened to provide data points for the entire tower. Facility limitations dictate that simulated lift-off be limited to four feet (232 feet actual) travel. Testing will be continued.

IV. APOLLO APPLICATION

A. S-IVB Workshop

1. Quick Release Manhole Cover, S-IVB Orbital Workshop

The purpose of this test is to evaluate and qualify a Quick-Release Manhole Cover for the Forward Fuel Bulkhead on the AS-209 S-IVB Stage for the SAA-209 Orbital Workshop Mission. The manhole cover is mounted to the Forward Bulkhead by an adapter ring which is bolted directly to the Forward Fuel Bulkhead. The manhole cover is attached to the adapter ring by 24 sliding wedges. The wedges are drawn into place by means of 12 turnbuckles. After final adjustment the turnbuckle is secured by a locknut tightened against the turnbuckle. The cover is removed by the astronaut while in orbit.

The test will functionally evaluate the wedge-cam retaining device; establish installation procedure and torque requirements for the manhole cover; evaluate the structural integrity of the manhole cover, while being subjected to the required environments; qualify the manhole cover seal with respect to minimum leakage rates; and qualify the seal used to prevent hydrogen leakage through the adapter ring bolt holes.

The test vessel is presently being modified at the ME Laboratory and should be delivered to R-TEST-CV during the first week of April. Two weeks will be required to install the tank, LH_2 and instrumentation system. Testing should then begin during the week of April 17.

2. Environmental Control System

This program, requested by R-P&VE-P, is required to support the thermal design of the S-IVB Orbital Workshop environmental control system. Tests are scheduled for a condensation model and a 1/8 segment of the workshop compartment liner. The condensation model tests will be used to confirm the analytical model being used to investigate condensation effects. Results from the 1/8 segment will provide data on heat transfer coefficients, fan performance, wall temperature, condensation rates, and curtain temperatures.

Buildup of the Condensation Model by R-TEST-CTE has commenced with testing scheduled to start within five weeks. Preliminary test planning meetings have been held with P&VE to establish the program for the 1/8 model segment of the workshop compartment liner.

W. L. Grafton

GEORGE C. MARSHALL SPACE FLIGHT CENTER
TEST LABORATORY
MONTHLY PROGRESS REPORT
ADVANCED FACILITIES PLANNING OFFICE
MARCH 1, 1967 through MARCH 31,1967

I. FACILITIES

A. R&A Projects

1. A project request is being prepared for modifications to building 4684.

2. Design criteria is underway for the 38'x 65' Vacuum Chamber.

3. Completion of design criteria has been accomplished and the following projects are awaiting start of design:

a. Helium Line Extension to Building 4650

b. High Pressure Air Pipeline

4. Design is underway on the following:

a. Project No. 7021 - GH_2 Transmission System - Phase II

b. Project No. 7023 - GN_2 Pipeline System, CTL Area

c. Project No. 7031 - Modifications to Provide Hydrogen Service at Test Stand 300 - Phase II

d. Project No. 6742 - GN_2 Connector Line

e. Project No. 7072 - S-II Structural Test Set-up.

5. Completion of design has been accomplished and the following projects are awaiting construction:

a. Project No. 7056 - LOX Trailer Parking Area

b. Project No. 6255 - Pavement Addition, Building 4653

c. Project No. 7058 - Steam Line Extension to LH_2 Test Facility

d. Fire Detection System

e. Improvements in the Vicinity of Building 4650.

6. Project for Installation of Cable and Cable Trays; East Test Area is being advertised for construction.

7. Construction is underway on the following projects:

a. Project No. 66-35 - Elevator at Liquid Hydrogen Test Stand

b. Project 7005 - Installation of Heaters, S-IC Test Stand

c. Project No. 7008 - Additional LOX Storage for All Test Positions, Building 4583

d. Project No. 7009 - Firex System Addition, Test Stand 115

e. Project No. 7013 - Elevator for Test Stand 500

f. Project No. 7018 - Transformer Substation, Test Stand 500

g. Project No. 7017 - Modifications to Scale House, Building 4659

h. Project No. 7021 - GH_2 Transmission System, Phase I

i. Project No. 7031 - Modification to Provide Hydrogen Service at Test Stand 300 - Phase I.

B. Nuclear Ground Test Module

The preliminary criteria for the Cold Flow Test Facility has been completed and will be forwarded to F&DO and R-P&VE-XN during week of April 17, 1967. No further work on adaptation of S-IC Test Stand for the Cold Flow Testing of the NGTM is contemplated until final design is initiated in FY-68.

C. S-II Structural Tests

Framing up requirements and initiation of steps for accomplishment of this program are underway.

J. B. Carrington

Karl L. Heimburg

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